BRAIDED SUSPENSION LINES

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Shroud lines have been manufactured almost exclusively in the braided construction during the entire modern developmental period of parachutes.

The characteristics of a braid are unique, and fit the requirements, as we now know them, of a properly constructed shroud line.

The more important of these characteristics include:

1. Equal flexibility in all planes.

2. All yarns acting as both warp and filling at the same time; and, as such, all bearing equal shares of the axial stresses - resulting in high efficiency and the maximum load-carrying capacity per unit weight.

3. Controllable geometry, with the resultant ability to control mechanical elongation.

4. A tubular construction, making possible the inclusion of a filler, similar to the gut of a webbing, but capable of being made a completely useful and load-bearing member by controlling its elongation to match that of the braided sleeve.

Studies completed since the last war tend to prove that the standard construction of the Type III, MIL-C-5040, is an adequate line. There is room for improvement, but there is no definite proof that this type line has any serious deficiences.

The investigation completed in 1946 by the Fabric Research Laboratories for the U. S. Army Air Corps, covering the "Impact Investigation of Textile Materials," confirms the fact that the standard nylon 26-pick, 550 pound test line has the best energy absorption characteristics of all the lines tested. In this report, however, it was recommended that this type of cord required further study from several standpoints:

It was suggested that increased pickage in the braid might increase the energy absorption. It was also pointed out that improved shrinkage techniques should be studied. There is the possibility of increasing the energy absorption as much as 80-100% compared with the present

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standard line, by treatment with steam at high temperature, and also by treatment with Formic Acid. Yields of this magnitude are worthy of serious investigation.

A subsequent report, by Kaswell of Fabric Research Laboratories, on the low-temperature properties of textile materials, again confirms the fact that the standard Type III line constructed of nylon shows good average properties at both 70°F. and at minus 70°F. In this report, as in the former one, Fiber A - now universally known as dacron - comes in for favorable comments, particularly for its performance at minus 70°F. There is a report due shortly, covering the study of textile materials at elevated temperatures, which all persons interested in shroud line manufacture are anxiously awaiting.

Let us turn, for a moment to the study of the Georgia Institute of Technology, Contract No. AF 33(038)10179, on the effect of twist on the properties of synthetic filament yarns.

In this study, nylon yarn stood out above all other yarns tested, with respect to its ability to absorb twist, and with respect to energy absorption at intermediate and at breaking loads. This study shows that twist usually contributes very few desirable properties - at least to the synthetic filament yarns. Nevertheless, it does show some points at which dacron is superior to all of the other fibers, including nylon. These points particularly are at high-twist levels.

There is, however, one effect of twist which was not studied, but which at this time would appear to be very important. This is the effect of twist on abrasion resistance of yarns, and/or fabrics braided or woven from such twisted yarns. It will be necessary to study this phase of the effect of twist before it will be possible to complete the design of the new experimental nylon coreless braids.

In Technical Note WCRT 53-105, the properties of such a nylon coreless braid are evaluated.

In the standard line construction, there is the problem of balance between core and sleeve yarns - not only when tested statically, but also when impact-tested. The coreless type braids have no such problem. Efficiency as to strength per unit weight is greater than in conventional construction, and it is possible to construct a cord of any breaking strength, merely by a combination of the proper number of ends of yarn. This type of line is currently being used in the G-12, 64-foot cargo chute, and by other services for non-human use.

All properties of the coreless type line appear to be satisfactory, or superior to the core and sleeve construction, with the one exception of the problem of poor abrasion - and snag-resistance. This, as noted in the above report, could be corrected by resin treatment; but immediately the factors of energy absorption, strength to weight ratio, and resistance to ageing, would require considerable further study. It is believed that the study previously mentioned, of abrasion resistance as a function of twist, would provide the answer to this problem.

Other studies published recently on the impact properties of yarns by the Quartermaster Research and Development Laboratories and the Textile Section of the National Bureau of Standards all continue to confirm the uniformly excellent results to be expected of nylon. But, in both of these reports, the polyester fiber dacron stands out as an excellent performer. Vinyl Chloride acrylonitrile copolymers show some interesting results, but high and low temperature tests must be performed to confirm the breadth of their usefulness.

All of these reports, from the original one in 1946, open many avenues of investigation for the improvement of shroud lines. However, when an attempt was made to reconcile the results published in these reports with the findings made by Pioneer Parachute Company in their "Investigation of Impact Load Absorption through Suspension Line Elongation," completed in 1952, we find many instances where the original premises derived from the earlier reports do not appear to carry through, and be directly transferrable, when the investigation is carried out on a complete chute.

It is this apparent inability to control all of the factors operating at the time of the chute opening, that has a tendency to bind the parachute industry to tradition - on materials, constructions, and designs.

Let us examine a few of the traditions, as outlined in Specification MIL-C-5040:

First, the breaking strength requirement. We can all remember when the silk shroud lines, under the original AN-C-63 Specification, had the requirement of 450 pounds breaking strength. Very properly, with an unknown fiber, such as nylon in the early 1940s, this requirement was increased to provide an additional margin of safety. Investigation on impact properties of textiles shows that the impact absorbing properties of silk are only in the proportion of 74 for silk to 177 for nylon cord, expressed in equals of inch-pounds per inch per denier. The ageing properties of nylon have now been accurately evaluated, so that it would no longer seem necessary to maintain this large margin of safety. Excessive shock loads can develop, not only from lines with low extensibility and high strength, but also from the use of over-sized, highly extensible lines. A revision in the strength requirement of the

specification would permit a saving in the cost of the line, and a reduction in the space requirements in the pack.

The specification sets forth three types of line and recent purchases for the new troop chutes seem to indicate that there is a trend toward the use of Type II, 375 pound test cord. Type II is not the cord that Type III is, even though they may look similar. The removal of three of the seven core ends results in a cord not properly balanced, as far as filling the central space is concerned. An intermediate cord of this tensile strength could probably be better designed by changing the size of the sleeve yarn, as was done in WADC Report 52-57 (Pioneer Report), Group 4. Or, a re-balance could be accomplished by making the braid of existing yarns, on a 24-carrier braider, resulting more nearly in a proportion of 50% sleeve and 50% core, as it exists in the Type III cord, which has served so well. This is probably a very poor suggestion, as there are very few 24-carrier braiding machines available. A better solution might probably be to further work along the lines of WCRT Report 53-105 and design a new coreless braid.

In review, it is suggested:

1. That a thorough study be made of the relation of twist to abrasion resistance.

2. That a thorough evaluation be made, at high and low temperatures, of dacron as compared to nylon.

3. That field trials be started on nylon shroud lines of the present construction, shrunk at high temperature and shrunk by the Formic Acid treatment.

4. That coreless shroud lines be actively studied, as they appear to offer many advantages, with but few disadvantages.

The present system of evaluating suggestions has, in the past, proved quite satisfactory, although we have always been amazed at the apparent lack of planes and personnel to perform drop tests at El Centro. Industry members have had ideas, developed them, and then submitted their suggestions to the Materials Laboratory for evaluation.

As the factors having important bearing on the functioning of suspension lines become more involved, the number of industry members in a position to do developmental work is considerably reduced. This will eventually mean that important contributions by industry members will be limited by their ability to do adequate testing. How many in the braiding industry today have equipment for the evaluation of impact properties of their samples, not to mention performing these tests at 350°F. and at minus 70°F.

In order that development may continue, it is felt that eventually a testing headquarters must be set up for the evaluation of samples, and the direction of investigation along certain channels, so that a coordinated program can be followed. These testing headquarters can be either a private concern, or installed at a plant of one of the line manufacturers, or can be set up here at Wright Field, where there is already a good start. But, direction and coordination must replace simple testing.

The will to advance is still as prevalent as ever in the braiding industry, but the tremendous impact of new fibers has so increased the number of possible combinations, that no uncoordinated program will be able to proceed rapidly enough to keep up with the technological knowledge required in the braiding of suspension lines.